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CONTENTS.

	PAGE.
Soil Surveys	141
The Banana in relation to Human Nutrition	143
A New Phosphate Fertilizer	146
Observations on Anaplasmosis in Antigua, B.W.I.	147
Review	148
Composts	149
Miscellaneous Notes	152
A Provisional Classification of the Soils of Trinidad	153
Modern Synthetic Rubbers	159
Chemical Notes	160

THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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SOIL SURVEYS.

We publish in this number a paper by Professor Hardy entitled "A Provisional Classification of the Soils of Trinidad". It is unnecessary to point out the local importance and interest of this paper. But it is hoped that even a worker in the colony where conditions are very different from those of Trinidad will find the paper well worth reading for the sake of the general principles which it illustrates, even if he does not find, as we hope he will, many facts of interest in the very highly condensed, but clearly expressed, mass of information which the paper conveys about Trinidad soils and crops.

One point to which such a reader's attention may be directed is the many years of intensive *ad hoc* studies of various parts and aspects of this subject which, as will be seen from the bibliography, preceded the beginning of the soil surveys proper. It is 13 years since Professor Hardy began an intensive study of the sugar-cane soils of Trinidad in an attempt to establish correlations between the characteristics of various soils and their susceptibility to the Froghopper pest. These studies, later continued and extended by Mr. P. E. Turner, employed jointly by the Sugar-cane Industry and the Agricultural Department as Sugar Agronomist, have led finally to the detailed formal description of the sugar-cane soils, which Mr. Charter undertook in 1938, which has been carried by one estate down to the unit of the individual field. Parenthetically it may be mentioned that it is only to-day that the full economic value of this work is seen in the correlations that have been found between the soil types and the results of manurial experiments and trials of the new Barbados seedlings—correlations which seem likely to lead to very profitable further increases in the yield of sugar per acre during the next few years.

Similarly, it is 11 years since Professor Hardy began his studies of the cacao, citrus, forest and various other soils of the colony in the course of the assistance which he gives to the other workers at the College in their investigations of the special problems of these various crops, and to the Forestry Department in its attack on the problems of the regeneration of forest species. But it is only four years ago that so much knowledge had been gained that the local Department thought it justifiable to employ Dr. E. M. Chenery as a whole-time specialist to undertake the actual mapping of the soils of Trinidad and Tobago.

In all this there is, we suggest, a moral for those African tropical colonies where the effective scientific study of agricultural problems began only in the 1920's. During that decade, there were not lacking enthusiasts for logical procedure in general, and for soil surveys in particular, who felt that the first action of the new agricultural departments of those new colonies should be to map their soils, as a necessary preliminary to the intelligent planning of any other work. "Without a soil survey you cannot", they said "even know how many experiment stations a colony needs, what area each station can serve, or where each station should be placed if it is to be 'typical of the area it serves'". They further pointed out, not without justification, that an Agricultural Department could obviously not confidently advise its Government about such matters as the colonization or utilization of land or the directions that roads and railways should take, so long as it had no soil map to guide its enquiries. On the other side were those who felt that, while there were many very obvious crying practical needs in each colony such, for instance, as large blocks of country and people entirely lacking a "cash" crop which they could grow and sell, and while there were existing export industries in danger of extinction because of the ill preparation of the product, an agricultural department could not properly spend its always limited funds on such a relatively academic study as a soil survey. "What", it is naturally asked, "is the use of soil surveying when one knows practically nothing of the crops and agriculture of the area surveyed?" The right policy lay, of course, between these extremes. It would be unwise and unjustifiable for a new department in a new country, lacking any real knowledge of local agriculture and local conditions, to spend large sums of money on soil surveys—at all events unless large and immediate schemes of colonisation or concession were involved. But on the other hand, it was essential that each of these departments should, from the beginning, have a soil science section which, while assisting the other departmental workers with their various problems, could immediately begin to accumulate the knowledge and the data upon which the soil map of the colony will one day be based. Working in this way, the soil chemist gradually acquires the preliminary knowledge of the soils and crops that must be gained before soil surveying and soil mapping can be intelligently planned. If the soil chemist, side by side with his other work, continually bears in mind the necessity for the eventual preparation of the soil map of his territory, and patiently plots all relevant data as it comes to hand, then the time will eventually come when it will be feasible and justifiable to undertake a formal survey so as to map the exact boundaries of the types that he will already have partially defined and roughly placed.

It will be seen that Professor Hardy and Dr. Chenery, in classifying their soils types (which in Trinidad at all events seem to be practically synonymous with soil series), begin by dividing them into soils with free, partially impeded and impeded natural drainage. Their next division is in accordance with the calcareous or non-calcareous nature of the parent materials of the soil. No one with knowledge of the problems of Trinidad agriculture to-day will, we imagine, wish to quarrel with this plan. It might not necessarily be the best plan in all countries. It is possible that 10 or 15 years ago, Professor Hardy would hardly have suggested these as the best primary divisions for a classification of Trinidad soils. It is possible, though not perhaps very likely, that 10 or 15 years hence, this may not appear so logical or convenient a system as it appears to-day. But this part of their classification system for the soils of Trinidad can be altered from time to time by the soil specialist without causing inconvenience to other workers. The system is like a card index. Provided the cards each refer to a convenient unit, they can be arranged and rearranged on whatever plan seems best for any particular purpose. It is the choice of the correct unit, the decision of what shall be given a card in our metaphorical card index that is of most practical importance to the soil specialists' colleagues in other branches of agricultural research. Professor Hardy and Dr. Chenery adopt a system in which the series, type and phase are closely analogous to the genus, species and variety of the botanist. It happens that in plant genera there are commonly several or many species, although genera containing only one species are not unknown. The exact opposite is the case in regard to series and types of soils. In spite of this, however, the analogy between the two systems is close. Soils are no readier than plants to conform perfectly with any system of classification, and soil chemists have consequently no more reached unanimity and finality about the classification of soils than have botanists about their species, sub-species, varieties and strains. As with plants, so with soils, agriculturists must remember that occasionally a difference which a specialist has to treat as a relatively minor one may be agriculturally more important than one to which the specialist gives a more dignified status. This is perhaps especially liable to occur in respect of very heavy or very light soils. Thus when there are two textural types of soils in a series, one of them may be quite light and the other not so light; and the difference between the types may be agriculturally more important than is sometimes the difference between two loam soils of different series. As regards types and phases the basis of the arrangement is more obvious. The whole matter of the classification of soils in the tropics is still fluid and systems vary from country to country and from time to time. This is inevitable at the present stage in the progress of the science; but it is to be hoped that soil scientists will resist the temptation to multiply terms and distinctions in this part of their classificatory system; and also that, like the botanist with his genera, species and varieties, they will base their conceptions of series, types, phases or the like on principles, which, however insusceptible they may be of completely satisfactory definition, are yet readily comprehensible by the layman.

THE BANANA IN RELATION TO HUMAN NUTRITION.

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World Trade in Bananas.

The banana export trade is of comparatively recent growth: the British market in particular has developed almost entirely within the present century; the American market began developing earlier, towards the end of last century. The industry has been continuously expanding; in the interval between the years immediately preceding the war of 1914-18 until 1937 the total world export in bananas more than doubled itself. The banana has risen to the status of a staple food in countries far removed from those in which it is grown.

The world production of bananas for overseas export during 1937* was more than two and a half million tons. This was concentrated mainly in Central and South America and in the West Indies, with Jamaica the largest single producer (359,000 tons), Mexico the second largest, (283,000 tons): many other countries in the neo-tropics contributed to a less extent. Total exports from British colonies were 459,000 tons. The internal trade in home-produced fruit within Australia and the Union of South Africa is not included in the figures considered here.

The United States was easily the leading importing country taking about half of the total export supplies (1,332,000 tons in 1937) with the United Kingdom a poor second (329,000 tons). It is, perhaps, not unreasonable to regard the potential import market of the United Kingdom, in normal times, as of the order of half a million tons if adequate supplies of attractive fruit are made available. The possible introduction into the market of fruit from existing hybrid plants resistant to the epidemic diseases Panama and Leaf Spot, at a lower price than the Gros Michel (the present standard export banana) may increase the sale of the banana among that section of the public whose purchasing power is small, to their benefit as well as the planter's.

Storage of Bananas.

During wartime the import of bananas into Britain, as of all foodstuffs, must depend on the available shipping but the value of this fruit in human nutrition makes it desirable to exert every effort to maintain or even increase the supply.† The refrigerated transport of bananas is a highly specialised trade and it is to be hoped that the specially-equipped banana vessels will not have to be diverted to purposes other than that for which they were designed.

The banana, like most tropical fruits, has a relatively short commercial life and even with modern methods of refrigerated transport and controlled ripening it is not a simple matter to place a fruit of good quality and size in the British fruit-seller's window. During wartime unavoidable irregularities and delays in the voyages of the banana-carrying ships will increase the difficulties and probably result in the selling of small-grade, possibly "chilled" fruit. Such fruit may be both unpalatable and indigestible. It is desirable that improvements in storage methods be sought and applied as quickly as possible so that an adequate supply of well-ripened, digestible fruit shall reach the consumer.

Scurti (1938) and Wardlaw (1940) have recently shown, by small-scale experiments, that ripening of the banana may be considerably retarded by refrigerated gas-storage, *i.e.* storage in atmospheres of low oxygen and relatively high carbon dioxide concentrations. Although considerably more experimental work is still required it is evident that bulk refrigerated-gas-storage of bananas will become a practicable proposition. This will enable larger fruit to be carried for longer distances than hitherto without risk of chilling, giving a good quality fruit for marketing. Of some immediate importance, perhaps, is the possibility of carrying fruit from plants infected with Cercospora Leaf-spot without the present losses due to ripening under refrigerated conditions with consequent chilling.

Fruit which has been successfully gas-stored has the eating qualities of well ripened fruit (*e.g.* ripening at 68°F. with or without previous refrigerated storage). From unpublished data it can be stated that the carbohydrate composition of such gas-stored fruit is similar to that of normal refrigerated fruit. There are not yet any data concerning possible effects on the vitamin content.

Composition and Quality.

The merits of any method of storage must be judged by the final eating quality of the fruit. Hence, as a basis, it is necessary to have information concerning the composition of a good quality fruit and in particular of those constituents which can be shown to be of primary importance in establishing the flavour and digestibility of the fruit. Various storage methods may divert the "normal" sequence of metabolic changes during ripening but provided the final chemical composition is that of a good quality

* Figures from the Imperial Economic Committee's survey on Fruit (1938).

† The importance of the banana as a staple food has been recognised in Britain by the issue of an Open General Licence under the Import of Goods (Prohibition) (No. 12) Order 1940, permitting the import of this fruit without special licence from *any* country as from March, 1940.

fruit such diversion will not be of importance. To ensure that this final composition shall be that of good quality fruit it is necessary to have knowledge not only of the good-quality fruit but also of the effects of storage (*i.e.* environmental) factors upon the metabolic reactions of ripening so that the desired composition may be assured in the fruit on the market.

The composition of the "eating-ripe" banana is by no means constant and the quality of the fruit available to the consumer varies considerably. Eating-quality is indefinable but is judged by the flavour, aroma and texture of the fruit pulp. Flavour depends on the chemical composition of the pulp; texture depends on the physical state of the various constituents. The flavour is a complex of sweetness from the sugars, bitterness and astringency from the glycosides and tannins, sourness from acids together with various subtle contributions to the whole taste and bouquet from esters, aldehydes and organic acids. The texture depends upon the state of turgor of the pulp cells and upon the amounts of cellulose, hemicelluloses, starch, pectin and other semi-solid or colloidal materials present.

Investigations of storage methods include investigations of the effects of external factors upon "quality". Enquiries into the nature of "quality" are being pursued side by side with storage trials and studies of general fruit metabolism under varied conditions. Some progress has been made with the analysis of quality in fruits of various storage histories but the complexity of the work is such that the present state of knowledge must be considered as merely the threshold to the subject.

The final "eating-quality" of a banana depends on the initial condition of the fruit on cutting and on its subsequent treatment during storage and marketing. The grade or level of maturity at which it is harvested determine to a considerable extent the length of storage which is possible; thus, heavy grade fruit given cold storage for a period suited to a lighter grade, when ripened are of inferior quality, described as "chilled" (Wardlaw, Leonard and Barnell, 1939). Fruit from plants heavily infected with Cercospora Leaf-spot disease have a slightly astringent taste in which esters, particularly amyl acetate, are more noticeable than in healthy fruit; but quality is lost more through the premature ripening of the fruit during cold storage with the appearance of "chilling" symptoms than directly from the disease symptoms. Fruit which has been subjected to refrigerated gas-storage after incipient ripening has already taken place has a poor eating quality. It is nearly flavourless, astringent and lacking in the characteristic bouquet of the banana, though from external observation the fruit may appear to be in perfect condition (Wardlaw, 1940).

Table I gives data representative of preliminary results obtained in the analysis of eating-quality in the banana. In this table the percentage amounts of various constituents of the pulps of good quality fruit and of poor quality "chilled" fruit are compared at, as nearly as can be judged, similar stages of eating ripeness. It will be observed that the slower ripening of the pulp of the chilled fruit will generally result in its being eaten while the starch content is relatively high and the sugar content relatively low compared with normally stored and ripened fruit. Sucrose tends to be low, glycosides and acid high compared with "normal" fruit. The difference in texture in "chilled" fruit gives rise to the characteristic "soggy" break as opposed to the "mealy" break of normal fruit; the possibility that this difference may be related to the hemicellulose and pectin content is under investigation. It has been observed that hemicelluloses are of considerable importance in the metabolism of the ripening fruit.

Table I.

Composition of "Normal" and "Chilled" Bananas when "Eating Ripe".

Grade and Treatment.	Eating Quality.	Percentage Fresh Weight.				Acid ml. N/10 NaOH, per 100 gm. Tissue.
		Starch.	Total Sugars.	Sucrose.	Glycosides.	
Heavy ¾-full. 8 days at 53°F. Ripened at 68°F. for 8 days	Excellent	3.74	11.52	3.39	0.35	58.2
As above. Ripened at 68°F. for 10 days	Excellent	1.71	12.63	3.82	0.23	59.4
Heavy ¾-full. 14 days at 53°F. 5 days at 68°F. ...	"Chilled"	7.52	6.59	1.89	0.24	66.0
As above. 7 days at 68°F.	"Chilled"	3.67	10.21	2.42	0.63	64.6
As above. 10 days at 68°F.	"Chilled"	1.62	11.25	2.36	0.66	61.0

Both "chilled" fruit and severely infected "Cercospora" fruit, when ripe, have a somewhat astringent taste; this has been related to the tannin content. The green fruit as cut from the plant contains large amounts of tannins both in the pulp and skin; these disappear to a great extent during ripening, apparently being oxidised to non-astringent substances. A method has been evolved* which, it is believed, provides an estimate of the free, astringent, tannic substances only. With this method the disappearance of free tannin during ripening has been followed in pulp and skin and the differences between fruits of different qualities estimated quantitatively. Both chilled fruit and fruit from Cercospora-infected plants have been found to contain higher percentages of tannin than healthy fruit ripened at tropical temperatures.

Nutritional Value.

The banana in the past has suffered from an unjustifiable belief held by many that it is an indigestible starchy fruit†. In truth the well-ripened banana contains a small proportion of easily digestible starch, much sugar, some protein and a certain amount of hemicelluloses; the residual substance, mainly cellulose, is small.

As long ago as 1890 H. M. Stanley in his book "In Darkest Africa" commented on the extreme digestibility of a banana product. During attacks of acute gastritis a native-prepared banana flour, made into a gruel, was the only food he could digest. In some cases of chronic indigestion very ripe bananas have been found to be the only source of carbohydrate that could be tolerated (Haas, 1924, quoted by Reynolds, 1927). Myers and Rose (1917) used bananas as a suitable easily digested and well-tolerated food in cases of nephritis where the supply of nitrogenous substances in the diet must be small. Banana powder or flour has been used with success in the feeding of infants, Blanchard (1936), Meysenbug and Fine (1936).

Calorific Value.

The banana is a rich source of energy, ranking higher than the potato: Banana 108 Cal. per 100 gm., Potato (old) 82, (new) 90. Excluding dry cereals it is amongst the cheapest energy-providing foods available to the English market. The banana is a valuable crop for local consumption because of its high yield per acre of food and energy; it has been stated that this yield, during a year can exceed that of any other crop (Reynolds, 1927).

Approximately 24 bananas will satisfy the energy requirement of an adult performing no manual labour (about 2,400 Calories). The relatively low amounts of protein and fat in the banana, however, render it unsuitable as a sole source of food. The addition of milk in suitable proportion to the banana provides a balanced ration adequate for all energy and tissue-building needs of the body.

Vitamins.

In industrial and other areas where fresh fruit and vegetables are not always easily obtainable the banana may provide a cheap and convenient source of the accessory food factors necessary to maintain full health. While the banana cannot be considered rich in any particular vitamin it contains A, B1, B2 (or G) and C in reasonable quantities; the antirachitic vitamin D is present in small amount only (DeCaro and Locatelli, 1937); there is little information available concerning vitamin E in the banana, though it has been reported present in small quantity (Evans and Burr, 1927, quoted in Hawk and Bergeim, 1938).

Vitamin A, the anti-xerophthalmic vitamin, supplies of which are necessary for efficient use of foodstuffs in growth and to maintain resistance to disease, is present in greater amount than in the apple. The Gros Michel banana amongst fruit, may be considered a good source of this vitamin (0.8 I.U./gm., Coward, 1938); (2.50 to 3.36 I.U/gm., Harris and Poland, 1937); (1.30 I.U./gm., Leong, 1939). There is a wide range of values for vitamin A content amongst different banana varieties; some varieties, grown in Malaya, have much higher amounts present than the Gros Michel (Leong, 1939).

B1, the anti-neuritic vitamin, is found in the banana in amounts considerably in excess of those in other fruits and in greater amount than in white bread. As a source of this vitamin the banana is equal to many brown and whole-meal breads (amount of B1 in the banana: (*a*) 0.5 I.U/gm., Baker and Wright, 1938; (*b*) .14 to .18 I.U.g/m., Harris and Poland, 1937).

The vitamin B2 complex includes the anti-pellagra vitamin. One determination of this vitamin for the banana is available and, in terms of Riboflavin (a constituent of the complex), is 0.0075 mgm. per 100 gm. (Kuhn, Wagner-Jauregg and Kaltschmidt, 1934, quoted by Fixen and Roscoe, 1938) and is higher than the amounts found in most fruits (*see* tables, Fixen and Roscoe, 1938).

There have been numerous estimations made of the vitamin C content of the banana and a wide range of values has been obtained. While the banana cannot be classed with the citrus fruits in its anti-scorbutic properties it has a useful amount of vitamin C and if eaten in quantity would give a measure of protection against scurvy. The values for ascorbic acid (vitamin C) in the banana given in Fixen and Roscoe's (1938) tables range from 0.01 to 0.15 mgm./gm.; the higher

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* Barnell, H. R.—Not yet published.

† This belief that the banana is a starchy fruit has received support from authorities, *e.g.*

(1) "Potatoes and bananas consist largely of starch. Fruits and many vegetables contain sugar", Plimmer, R. H. A. and Plimmer, Violet G. (1929).

(2) "As a typical starchy fruit the banana may be considered . . ." Armstrong, E. E. and Armstrong, K. F. (1931).

values probably being most accurate according to recent investigations into the technique of vitamin C determination (Thornton, 1938). It is interesting to note that unripe bananas have a higher vitamin C content than ripe. The plantain (in many respects similar to an unripe banana) may have a vitamin C content ten times as great as a ripe banana (Rudra, 1936).

Mineral Salts.

The banana in common with other fruits, yields an alkaline ash (0.6 to 0.8 per cent. of the fresh weight of the pulp) containing over 50 per cent. potash; the remainder includes such important nutritional elements as phosphorus, calcium and iron. These elements are, in general, present in greater amount in bananas than in either apples or oranges. The importance of calcium and phosphorus in bone and tooth formation and general nutrition is well known. It has been stated that all the iron in the banana is in a completely available form and can be utilised in the formation of haemoglobin (Smith and Otis, 1936).

The virtues of the apple in the diet have long been appreciated and much research work has been done to ensure a constant and ample supply of this fruit for the consumer. The banana is, on every count, a more valuable fruit. It is an unusually hygienic food due to its relatively thick and resistant skin; it has a higher mineral content and a higher calorific value, weight for weight, than the apple. Its protective food (vitamin) content is more diverse than that of the apple and is greater for those vitamins common to both fruits.

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A NEW PHOSPHATE FERTILIZER.*

A practically water-insoluble and non-hygroscopic form of potassium metaphosphate can be obtained by the action of phosphoric acid on potassium chloride. Analyses made in accordance with the Official Methods of Analysis of the A.O.A.C. for citrate-insoluble phosphoric acid and for potash in mixed fertilizers indicate that, owing to the solubility of this metaphosphate in ammonium citrate and oxalate solutions, the phosphorus and potassium are readily available to plants. Vegetative tests support this conclusion. The high nutrient concentration of potassium metaphosphate [39.87 per cent. potassium oxide (K_2O) plus 60.13 per cent. phosphoric oxide (P_2O_5)] should permit important economies to be made in bagging, handling, shipping, storage, and tax charges per unit, and thus make it particularly well adapted to economic distribution over wider areas than other fertilizer materials.

* (Abstract from *Potassium Metaphosphate*, A Potential High-Analysis Fertilizer Material, by S. L. Madorsky and K. G. Clark, appearing in *Industrial and Engineering Chemistry*, **32**, 2, p. 245, 1940.)

OBSERVATIONS ON ANAPLASMOSIS IN ANTIGUA, B.W.I.

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Introduction.

The object of this paper is to report on a clinical case of Anaplasmosis* in a dairy cow and definitely to establish the incidence of this disease in Antigua, B.W.I.

The writer has suspected for a long time that infestation with this blood parasite was present amongst cattle in the island, but many attempts to confirm a diagnosis by positive blood smears were unsuccessful although the clinical symptoms were suggestive of Anaplasmosis.

While considered as a tropical or sub-tropical disease and found in places such as Brazil, Argentina, Central and South Africa, Formosa, and the Philippines, Italy and other European countries, it has also been found in many parts of the U.S.A. With regard to its distribution in the West Indies, the writer encountered many cases while in Jamaica, and it has also been found in Barbados and Trinidad.

As to the nature of the disease, Stiles (1) defines Anaplasmosis as an acute or chronic, febrile, infectious, protozoan disease, characterized by loss of flesh, laboured breathing, suspension of milk flow, anaemia, jaundice and marked degenerative changes in the red blood cells. The cause of these changes is a microscopic parasite, *Anaplasma marginale*. The minute organisms are transmitted from one animal to another mainly through the agency of tick bites. However, the rôle of biting flies and mosquitoes as vectors of the disease cannot be overlooked and infection can also be carried from one infected animal to another by means of blood contaminated surgical instruments.

Case Report and History.

The subject, a four-year old Holstein cow had been imported from Barbados, B.W.I. in November, 1938, along with seven others.

The following information with regard to the management and general health of these animals is very kindly supplied by the owner, Hon. A. Moody-Stuart, through the co-operation of his retained Veterinarian Dr. A. L. Raeburn :—

These animals were imported for dairy purposes and were carefully selected in Barbados from different herds. They arrived here in good condition and were kept isolated from local animals for three months. After this period they were allowed to mix with other animals and placed in a paddock which had been previously used. Their general health was quite good and they were sprayed regularly to control tick infestations.

Dr. Raeburn reports that in October, 1939, one of the animals became ill and exhibited symptoms which were very suggestive of Anaplasmosis. At the *post mortem*, the findings here were also suggestive. No definite diagnosis was however made. After the death of this animal, the herdsman was warned to keep a careful check on the animals, especially as to their freedom from ticks and to report immediately on any signs of illness, especially any jaundiced appearance.

On 6th March, 1940, the writer, deputizing for Dr. Raeburn, who was on sick leave, was called into another of this group of cows. The following is the case report :—

Subject.

Four-year-old Holstein cow.

The animal was observed to be off feed, and badly jaundiced. When first seen on 6th March, 1940, it had a very gaunt and dejected appearance and exhibited symptoms of marked debility. The temperature was 105°F, pulse rate 90 and respirations 40.

The most aggravated symptom was the severe jaundice—the skin, udder and teats, eyeballs, tongue and gums were all very yellow and anaemic. The animal, while not off food completely, was not eating very much and there was not much bowel activity presumably as a result of marked bile stasis. Its milk yield had also decreased.

Anaplasmosis being suspected, blood smears were taken at this juncture as well as a careful search made on the animal for ticks. It was very difficult to find any of these and only three specimens were secured, which were forwarded to Dr. F. C. Bishopp, U.S. Dept. Agriculture, Washington, for identification.

The blood smears were examined and found to contain *Anaplasma marginale*, about a ten per cent. invasion of the red blood cells being present. These smears were also forwarded for confirmation to Dr. G. Dikmans, U.S. Dept. Agriculture, Washington.

At this juncture the treatment consisted of an intravenous injection of sodium cacodylate, 4 gms. (60 grs.) in 150 c.c. distilled water. A saline purge of Glauber salts, 1 lb., was also given.

When seen the next day, 7th March, 1940, the general appearance was slightly improved. The temperature was down to 103.8°F., the bowels were loose and the animal was eating moderately well. Further treatment at this time consisted of another intravenous injection of sodium cacodylate, 6 gms. (90 grs.).

On the following day, 8th March, 1940, the temperature was down to 102.4°F. and improvement continued. On 10th March, 1940, the temperature was 102°F. and from this stage on the recovery of the animal was slow but uneventful. A tonic mixture of arsenic, strychnine and iron was dispensed. When seen about four weeks later the animal was doing well.

* Commonly known as Gall Sickness.

Confirmation of Diagnosis.

The blood smears were confirmed as being positive for *Anaplasma marginale* by Dr. G. Dikmans, in charge, Ruminant Parasite Investigations, U.S. Dept. Agriculture, Bureau of Animal Industry, Washington.

The tick specimens were identified as being the tropical cattle fever tick, *Boophilus annulatus microplus* by Dr. F. C. Bishopp, Principal Entomologist, Insects Affecting Man and Animals, U.S. Dept. Agriculture, Bureau of Entomology and Plant Quarantine, Washington. Dr. Bishopp reports that this species of tick is a recognized carrier of Anaplasmosis.

With further reference to known carriers, there is the presence in the island of another tick *Rhipicephalus sanguineus* reported by Goodwin (2).

Discussion.

This case is an interesting one as it records and confirms the presence of Anaplasmosis in the island and shows that there is a great difference between imported and local animals in the degree of resistance to this infection. However, we would expect to find more resistance in animals from Barbados where the disease is already known. This raises the question as to whether there are individual degrees of virulence of the parasite in different localities.

Another interesting point is the length of time elapsing before the disease showed up in these animals, almost a year after their arrival here. One would have expected to have the infection showing up soon after arrival and not after a year of acclimitization to local ticks and other conditions.

That the degree of resistance to Anaplasmosis by local animals may be very high, is suggested by the failure to find any cases amongst them. The writer has made numerous blood smears suspecting this parasite but all with negative results. Dr. Raeburn reports a similar experience and has not found any cases in local animals.

With regard to the losses from this disease, there is not only the death of the animal in some cases but always the loss of flesh and condition as well as the stunting effect on growing animals. Furthermore, in dairy animals, milk production is generally seriously affected. Animals in advanced pregnancy may abort.

Summary.

1. The occurrence of Anaplasmosis is reported and confirmed in Antigua, B.W.I.

2. A clinical case report of this disease in a dairy cow is given as well as history involving this animal.

3. General discussion.

Acknowledgments.

I wish to acknowledge my gratitude and thanks to the following for their help and co-operation in preparing this report:—the Honourable A. Moody-Stuart, Tomlinsons, Antigua; Dr. A. L. Raeburn, Five Islands, Antigua; Dr. G. Dikmans, in charge, Ruminant Parasite Investigations, Bureau of Animal Industry, Washington, D.C., U.S.A.; Dr. F. C. Bishopp, Principal Entomologist, Insects Affecting Man and Animals, Bureau of Entomology and Plant Quarantine, Washington, D.C., U.S.A.

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REVIEW.

LA CANA DE AZUCAR.

By Dr. William E. Cross, *Universidad de Buenos Aires*, Argentine, 1939, pp. 231.

The first 55 pages of this book are devoted to the reproduction of a popular lecture delivered before sugar planters and manufacturers at Buenos Aires. It summarises the important part played by Science in the evolution of the sugar industry to its present state of efficiency. The author traces, if only in a cursory manner, the history of the plant and of the manufacture of sugar therefrom, stressing the various problems as they arose and how they were met by the application of science. This achievement has been the result of the combined effort of the plant breeder and agronomist as well as of the chemist and engineer, each of whom still continues to contribute his share for the improvement of the industry and its maintenance at its present-day high level.

The second part of the book consists of a series of lectures delivered to Third Year Students of the Faculty of Agronomy and Veterinary Science of the University of Buenos Aires. It covers all the important aspects of the sugar-cane plant: the botanical description of the plant; its chemical composition; climate and soils suitable for its cultivation; breeding varieties specially adapted to varying conditions; cultural methods; diseases and insect pests; harvesting; and yields and costs with reference to Argentine. 150 pages can hardly be sufficient for a full treatment of any of those subjects, but Dr. Cross has certainly succeeded in providing a very valuable synopsis for the Spanish reading student. He is very successful in arousing in the mind of the reader a keen appreciation of the complex relationships existing between the plant and its environment. For anyone desiring more detailed knowledge, a bibliography is provided of the best known text-books, as well as of periodicals published by the various sugar-producing countries of the world.

This book is profusely illustrated by well-reproduced plates throughout, among the best of which are the coloured plates illustrating nutrient deficiency symptoms developed in the leaves.

G. R.

COMPOSTS.*

Composts in the Old Days.

Composts were formerly much used in British farm and garden practice, and the art of making them was well developed in the middle of the last century when labour was cheap and abundant, and prices of farm produce relatively high. J. Hannan, of Kirk Deighton, Wetherby, Yorkshire, a well-known farmer-writer of those times, describes in Morton's *Cyclopedia of Agriculture* how they should be made. Three kinds were recognised: Farmyard manure composts, lime composts and earth composts. The farm yard manure composts were made by building up alternate layers of farmyard manure and of vegetable waste, each about one foot thick: the surface of the heap was then covered with earth. After the mass had undergone decomposition, the heap was turned and well mixed, then remade and again covered with earth or ashes. The vegetable waste could consist of sods, peat or turf, leaves, heath, moss, rushes, weeds, hedge clippings, seaweed, &c.

Another method used where no farmyard manure was available consisted in making the heap of vegetable waste only, and watering it with liquid manure: he instances a farm where the couch grass gathered from the fallows, and the harrowings of weedy stubbles, especially of beans and peas, gave by this method 200 cart loads of good compost in one summer: a testimony to the profitable use of liquid manure and the weediness of the farm.

Special attention was devoted to the composting of peat in Scotland and Ireland. The peat was left to dry for a few months, then made into a heap of alternate layers, the peat layer being 6 in. thick and the dung 10 in., then peat 6 in. and dung 4 in. and so on. The dung should be fairly fresh, but the heap required watching to see that it did not get overheated and 'fire fanged': in that event it had to be watered.

Alternatively, lime was used instead of farmyard manure, but much less was needed; one measure of lime was recommended for five of peat, but for other vegetable wastes the amounts were not specified.

Earth alone, or soaked with urine or liquid manure, was also used.

The making of compost heaps involved a good deal of labour and it gradually went out of use with the shift towards grass instead of arable, the rising cost of wages, and the fall of prices.

Many gardeners, however, continued to compost their vegetable wastes, making up the heap and in some cases watering it with household slops which were found to facilitate the rotting.

Modern Methods of Composting.

(*a*) *Inorganic Accelerators.*—The subject was put on to a proper scientific basis in 1921, (1) by H. B. Hutchinson and E. H. Richards, who showed that the decomposition of the organic matter in the vegetable wastes (which is the basis of compost making) depended on an adequate supply of air, moisture and food for the organisms that bring it about, and the avoidance of acidity that would hamper their activities. The most favourable temperature is about 100°F.-120°F., but this develops by itself if the other conditions are satisfied: the temperature may rise to 150°F. without harm, but water should be added to make good the loss by evaporation.

For straw containing 0.5 per cent. of nitrogen, they found it necessary to add another 0.72 per cent. If more was added it was wasted, but if less, decomposition was greatly retarded. The source of nitrogen could be animal excretions, notably urine, as in making farmyard manure, or, alternatively, sulphate of ammonia, cyanamide, or similar quick-acting material: where sulphate of ammonia was used, some $\frac{3}{4}$ cwt., together with 1 cwt. finely-divided carbonate of lime, sufficed to treat 1 ton of straw. Cyanamide did not require additional lime. Phosphate might also be needed.

The practical difficulty of rotting straw on the large scale is to get it wet; when this is done and the nitrogen compound added, decomposition proceeds quickly, giving a well-rotted manure.

About 40 per cent. of the original organic matter is lost, but the loss falls entirely on the carbonaceous part and none on the nitrogen. Even when exposed to rain, the compost loses only little nitrogen, in contrast with farmyard manure, which may lose 30 or 40 per cent. Potash is liable to be lost, but not phosphate. In view of these low losses, it is unnecessary to protect the heaps against rain; on the contrary, they should be exposed and flat-topped so that the rain water can soak in and provide more moisture for the organisms. When the work is properly done, 1 ton of straw can make 3 tons of compost; during the process it requires about 800 gal. of water and from $\frac{3}{4}$ to $1\frac{1}{2}$ cwt. of the chemical food, according to its composition.

In order to ensure that the discovery should not be improperly exploited, a patent was taken out and worked by a non-profit-making syndicate, the moving spirit of which was the Earl of Iveagh. Steps were immediately taken to examine large numbers of vegetable wastes; their nitrogen requirement was determined and direct tests were made to see if decomposition proceeded normally with each one.

* An article by Sir E. J. Russell, Director of Rothamsted Experimental Station. Reprinted from *The Jr. of the Min. of Agric.* Vol. XLVI, No. 8, pp. 751-58, 1940.

The nature of the carbohydrate constituents plays an important part in the decomposition, and hard lignin-like material has to be balanced by the addition of softer cellulosic material such as leaves, grass, &c.

In general, however, it is not recommended that woody substances, such as hedge trimmings, prunings, &c., should be composted; they are better burnt.

The heap is made in a shallow pit dug about 2 ft. deep but the excavated soil is put round the sides so that the actual depth becomes much greater. The vegetable waste while still fresh, is laid in a layer of about 6 in. and wetted if necessary: the chemical is then added at the rate of 1 part to 20 of dry matter of the waste, which works out to about 2 lb. per large barrow load. New layers are then added till the heap is sufficiently high: it is then left for 2-6 months, during which time, however, it should be turned at least once, otherwise the top layer remains undecomposed. Sufficient heat is generated to kill seeds of annual weeds, but one cannot be sure of destroying fresh roots of bindweed, couch grass, dock and similar resistant weeds: these are better burnt.

Grass cuttings should be mixed with about 10 per cent. of straw so as to ensure a more even type of decomposition.

Good composts made from garden rubbish may contain as much nitrogen as farmyard manure, and more phosphoric acid and potash. The averages of E. H. Richard's samples were:—

Percentage Composition.

	Dry Matter.	Organic Matter.	Nitrogen (N).	Phosphoric Acid (P_2O_5).	Potash (K_2O).
Compost from garden rubbish	29.3	13.0	0.66	0.60	1.12
Ordinary farmyard manure	23.9	18.9	0.53	0.23	0.56

Much work has been done on the subject at the Cheshunt Experiment Station under Dr. Bewley. Straw decomposed by 3½ months' composting by the Adco method proved as useful as the long horse manure favoured by glasshouse growers.

Many thousands of tons of compost have been made by this method, especially by nurserymen and market gardeners in Great Britain and by planters overseas.

Other methods of supplying the food for the organisms are used. Dr. M. A. H. Tincker, informs me that at Wisley compost is made from all garden rubbish, including oak and chestnut leaves from the common, woody twigs from Hornbean hedges, &c. The heaps are about 22 yd. by 4 yd. by 5½ ft: the 'starter' used is sulphate of ammonia and a little powdered chalk: and the heaps are watered with a garden hose. The time required depends on the proportion of soft grass clippings: if this is adequate, six months in winter is usually long enough for the making of a good manure.

Pine needles should not, however, get into the heap; they are liable to diminish the value of the compost.

(*b*) *Farmyard Manure as Accelerator.*—Where farmyard manure is available, it can be used as in the old days for composting. On the Continent, a modification of Kranz's so-called hot fermentation method (designed for making high-grade dung) has been used. The vegetable waste is mixed with dung to form the foundation layer of the heap: daily additions go in turn to quarters of the heap, each lot being left loose and open until it becomes hot; it is then trampled down. Four such layers are made, each of them in the first instance 2-3 ft. thick. Each is trodden down and moistened uniformly with dilute liquid manure. During the first or aerobic decomposition, the temperature rises sufficiently to kill weed seeds: after it is compacted, anaerobic decomposition continues. The final heap is about 10 ft. high, and is covered with earth and left for 3 to 5 months.

At Cheshunt, good results have been obtained by a much simpler method: compost is made of thin layers of horse manure sandwiched between thicker layers of straw. Composting is not even necessary: straw can be sprinkled with sulphate of ammonia or a complete fertilizer, and put straight into the soil; in farming practice, ploughed down.

(*c*) *Easily Decomposable Vegetable Matter as Accelerator, The First Indore Process.*—Composts are particularly important in those tropical countries where farmyard manure is used as fuel and where, therefore, other methods of manuring the land have to be adopted.

India is a notable example, and Hutchinson and Richards' work proved of great importance there. The particular sources of nitrogen used in England were not very suitable, but alternative sources were found. In the so-called Indore method devised by Sir A. Howard the source of nitrogen is young vegetable matter containing more nitrogen than is needed for its own decomposition, and, therefore, with nitrogen to spare for decomposition of material inadequately supplied. The difficulty about water supply is minimized by putting earth into the heap; this holds water and so ensures a reserve that prevents the heap drying out. In parts of India it is possible to obtain earth from cattle stables, and the urine supplies nitrogen for facilitating decomposition (2).

(*d*) *Habitation Wastes as Accelerator.*—Yet another method, also from Indore, was worked out by F. Keith Jackson and Y. D. Wad, where habitation wastes and human excreta and the ordure that otherwise lies about the streets of an Indian village were used. This furnishes nitrogen

for the decomposition and has the advantage of encouraging public cleansing of the villages: even if the material had little fertilizer value the process would still be worth while for the sake of keeping the village clean.

Dr. Gilbert Fowler has also worked out a method using habitation wastes and human excreta. Others have been studied at Bangalore (3). Methods of this type are of obvious importance in places where there is no water-borne sewage system, and where, therefore, excrementitious material is available.

Materials Used for Composting on the Farm.

In gardens, nurseries and market gardens where no animals are kept, there is a supply of material of various kinds for composting, but on most English farms there is generally very little that in practice can be composted. Such things as sods, weeds, leaves, moss, &c., do not usually occur in sufficient quantity to make composting possible. Leaves of mangolds are far more conveniently ploughed in, so also are green manure crops; sugar-beet tops are better fed to animals and hedge trimmings must in any event be burnt. Potato haulms are a possibility and, as shown later, there is no clear evidence that diseases survive composting. In some districts, however, peat can be obtained.

Peat for Composting.—Peat has proved useful as material for composting. In horticultural work, its value is well established and before the war a good deal was imported into this country from Germany and used for this purpose. Methods of making composts for potting have been described by Lawrence and Newell of the John Innes Horticultural Institute (4). Experiments on the making of peat composts for manure on an agricultural scale are being made by the Macaulay Institute in Lewis, thus reviving an old Scottish practice: good results were obtained from a mixture of 10 tons peat, 1 ton farmyard manure, 5 cwt. basic slag and 2 cwt. 30 per cent. potash salt. Considerable heat is developed, and after some months the material breaks down to a dark brown, dry, friable mould which makes an excellent manure (5). The investigations are still proceeding, but it appears that sphagnum peats take longer to compost than *Eriophorum* (Cotton grass) peats, and these longer than fen peat.

Waste Straw for Composting.—The commonest waste materials are those thrown out from the threshing machine, and straw in excess of animal requirements and not saleable or otherwise usable. Threshing waste, however, contains many weed seeds, and farmers are rightly nervous about using it as a source of manure, hence it is usually burnt. This is certainly the safest and, in present circumstances, probably the best procedure.

We are finally left with waste straw (i.e. straw which cannot be made into farmyard manure by the animals) as the only practicable material that can be composted, but this constitutes a really difficult problem which, on the farm, has not yet been solved in spite of many efforts at Rothamsted during the past seven years. The first difficulty is to wet the straw uniformly, and short of putting it into a tank of water or passing the straw through a special machine that cuts the straw, waters it, and adds the accelerator, no satisfactory way of doing this has been found. Samples made at Rothamsted by setting up the heap, watering from the water cart and the rain, yielded poor material containing 0.3-0.45 per cent. of nitrogen, 0.25-0.35 per cent. of phosphoric acid (P_2O_5) and 0.16-0.3 per cent. potash (K_2O), which gave definitely poorer results than farmyard manure. Attempts have been made to dilute farmyard manure with straw: these are still going on, but as yet with little promise of success. In an experiment with potatoes, dung (15 tons per acre) alone was compared with dung (the same-sized dressing) *plus* 2 tons chopped straw. The addition of the straw was of no visible advantage: indeed, there was a slight but not significant depression in yield of the potatoes and no significant benefit to the succeeding oat and clover crops.

A very ingenious method of composting straw was devised by E. H. Richards and put into operation at the Wainfleet camp during the 1914-18 war. The straw was set up in the form of a filter in three sections over which the sewage from the camp was passed. The micro-organisms multiplied rapidly and absorbed the nitrogen, decomposing the straw and producing a good manure rich in nitrogen, and at the same time purifying the sewage and converting it into a harmless effluent (6). The method was tested at a Land Settlement and gave very promising results: it might be desirable to revive it. So far, the simplest way of dealing with excess straw is to put it on the land in winter or early spring, add a dressing of cyanamide or sulphate of ammonia as accelerator, and plough it in, leaving it to rot in the soil.

Do Plant Diseases Survive in Composts?

It is not possible to state definitely whether plant diseases are, or are not likely to be spread through diseased material that may have got into the compost heap. No direct experiments have been done on the subject. Bewley found that tomato stems and leaves carrying spores of *Verticillium* disease were dangerous in the compost heap and badly infected the next crop. On the other hand, there is no evidence that the spores of ordinary blight (*Phytophthora infestans*) would survive composting of potato haulm, though Wart Disease and Pink Rot might do so. In gardens it is impossible to avoid diseases completely, and while certain of them, such as virus diseases and others, would not be likely to survive the composting process, others caused by organisms producing highly resistant spores might do so. Possibly Finger and Toe would survive; it is known that its spores remain viable when passed in the dung of cattle and sheep (7).

Evidence of the Value of Compost.

In view of the great amount that has been talked and written about composts, there has been surprisingly little field experimental work on the subject. There is little doubt that well-made compost has considerable fertilizer value, but actual figures are almost entirely lacking, and therefore no comparisons with artificial fertilizers or farmyard manure are possible, nor are figures of cost under English farm conditions available.

A good deal of compost has been made on tea estates in North India, where the necessary vegetable matter is easily collected from the uncultivated land near the estates. The collection of this material has, however, in places led to bad soil erosion.

It is stated that the results are best when sufficient quantities of cattle or other animal manure are available : they are said to be less satisfactory where the animal material has been deficient (8). Attempts to run the tea estates on compost alone, however, proved unsatisfactory: it was necessary to provide the proper artificials.

There has been much discussion among tea planters as to whether green material should be worked into the soil as green manure or made into a compost. On this subject, definite and good experiments have been made by H. R. Cooper, at the Assam Tea Research Station, and by T. Eden, of the Ceylon Research Institute. In no instance was there any evidence of the advantage of composting, and tea planters are now, therefore, recommended to dig in their green manures.

General Conclusions.

The value of well-made composts in gardens, market gardens and nurseries is beyond doubt, though incontrovertible figures are not available to prove this. The accelerator may be inorganic, such as sulphate of ammonia plus chalk or limestone cyanamide, Adco or other easily available nitrogenous compound: with the two former, phosphate is also needed ; or the accelerator may be farmyard manure : easily decomposable vegetable matter : habitation wastes, household slops containing nitrogenous matter, &c. The value of composts on the farm is not yet established. The material most generally available is straw, but the difficulty of proper water supply is not yet overcome, and composts made with unsatisfactory water supply have not proved particularly effective. The better utilisation of waste straw on the farm is among the most important agricultural problems.

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MISCELLANEOUS NOTES.

Tung Oil.

The supply of tung oil has been so profoundly affected by the war in China that considerable interest is attached to a report by Dr. M. Ashby upon his tour of the area in the United States in which the tung tree is now being cultivated (*Bull. Imperial Inst.*, 38, No. 1 ; 1940). It is estimated that some 175,000 acres in the States bordering on the Gulf of Mexico now carry plantations of this tree, but many earlier plantations were on land that has since proved unsuitable, the great difficulty proving to be frost damage. The species cultivated is almost exclusively *Aleurites fordii* Hemsl.

Details are given of cultivation, harvesting and mill treatment of the crop, &c., and it is clear that a very high-grade quality of oil can thus be obtained, but until 1938 the yield had been uncertain owing to frost damage. Although three million pounds of tung oil were produced in the States in 1938 (against an import of 108 millions in that year), until now the paint and varnish industry practically bases itself upon the Chinese supply, though the war has made this a very uncertain source.—(*Nature*, Vol. CXLV, No. 3680, p. 738, 1940.)

Cinchona Production in the Netherlands Indies.

An article by Dr. M. Kerbosch in the *Bulletin of the Colonial Institute of Amsterdam* (3, No. 1, December, 1939) gives some notes on cinchona culture and the world consumption of quinine. Existing plantations in the Netherlands Indies could produce considerably more than the present world consumption. The Netherlands Indies Government has at its disposal sufficient guarantees to prevent the agreement between the manufacturers and producers being used in a way which would hamper malaria control. Cinchona growers would welcome the opportunity to increase their output, and the agreement, which has united practically all producers and manufacturers, makes it possible to put regularly at the disposal of malarial areas large quantities of quinine for longer periods. Obstacles to the use of this super-abundance of the Java cinchona estates are largely financial and technical. Disbursements for defence in all countries cripple other projects, including health or hygienic measures. In addition, malaria control with quinine requires an efficient administrative machine for the distribution of the drug under medical supervision. For mass treatment of malaria, quinine is unlikely to be replaced by other cinchona alkaloids or synthetic drugs.—(*Nature*, Vol. CXLV, No. 3680, pp. 738-39, 1940.)

A PROVISIONAL CLASSIFICATION OF THE SOILS OF TRINIDAD.

By F. Hardy.

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[*The following article is based on an unpublished 29-page typescript report to the Director of Agriculture of Trinidad and Tobago, describing a Reconnaissance Soil Map and a Tentative Land Productivity Map of Trinidad compiled in May, 1939, by Dr. E. M. Chenery (Soil Chemist, Department of Agriculture), as an outcome of three years' intensive work in continuation of investigations on the soils of the Colony begun in 1929 by the College Department of Chemistry. Copies of the Tentative Land Productivity Map of Trinidad, which it was not possible to include with this article, and separate copies of the Table appearing at the end of this article, may be purchased from the Editor, "Tropical Agriculture", Imperial College of Tropical Agriculture, St. Augustine, Trinidad, B.W.I. The writer wishes to express his indebtedness to the Director of Agriculture and to Dr. Chenery for permission to publish this article.*]

Introductory.

The provisional Soil and Land Productivity Maps recently issued by Dr. E. M. Chenery (but not here reproduced) present all the available information* in a form suitable for the use of administrators, economists, agricultural officers, planters, public health officers and others interested in the welfare of the Colony. They are admittedly not equally reliable for all parts of the Island, though the degree of accuracy of each section is indicated by an inset map. So far, only about one-quarter of the whole area has been accurately mapped, but Dr. Chenery intends to complete the mapping during the next three or four years, and eventually to publish a bulletin fully describing the soils of the Colony, illustrated by a series of maps. The present report is therefore to be regarded as tentative; the classification scheme is liable to alteration or modification before final adoption.

Classification of the Soils.

The scheme of soil classification formulated by Dr. Chenery and presented in tabular form herewith, with some slight modification, is essentially practical in nature. First consideration is given to *natural drainage*,† which is determined by topography and soil structure. Drainage largely controls the important moisture and air relations of the soil, at least within regions that are climatically uniform, such as Trinidad.‡

Soil structure is partly decided by texture (size and assortment of grain), partly by the arrangement of particles, and partly by cohesiveness. *Texture* is expressed as degree of sandiness or clayiness, but *particle arrangement* and *cohesiveness* are expressions of many chemical and physical factors, among which calcium content is particularly important. Thus, soils abundantly supplied with *lime*, such as those derived from calcareous parent materials, generally exhibit an open, permeable, crumby structure, particularly well suited for high crop production. Both texture and lime status are accordingly considered in the classification scheme.

Next in importance is *plant nutrient* status, decided by the contents of available nitrogen, phosphate and potash. While it is known that the chief source of soil *nitrogen* is organic matter, the organic status of soil is important for other reasons, some physical and some biological, and is therefore afforded special prominence. Available *phosphate* and *potash* contents are partly decided by the mineralogical composition of soil; they may be measured by standard laboratory methods, such as those employed in the routine analysis of the soil samples collected during the Trinidad soil survey.*

Finally, the absence of *harmful factors*, such as aluminium and sodium salts and organic toxins, is essential to fertility; the occurrence of harmful factors may often be gauged from the degree of acidity or alkalinity of the soil, which was also determined on the soil samples.

The summarised laboratory data for lime, organic matter, phosphate and potash status are shown by numbers in a three-category scheme in the table. Together they express the *fertility*

* A list of references to recent literature on the Soils of Trinidad is appended to this article. (F.H.)

† Predominance of natural drainage as a main factor in soil classification was suggested as long ago as 1929 by Prof. G. W. Robinson for the soils of North Wales (see *Nature*, 1929, Vol. 123, p. 980). (F.H.)

‡ The annual rainfall of Trinidad ranges from 50 to 150 inches, but in the cacao belt, only from 70 to 110 inches. Wet and dry seasons alternate, but they are less marked in the wetter eastern part of the Island. The highest altitude is below 4,000 ft. and not more than 1,000 ft. in the cacao belt, so that temperature variations are not large, the air temperature being seldom lower than 65°F. nor higher than 87°F. (F.H.)

* Altogether, some 4,800 soil samples have been analysed for the purposes of this survey. Each sample has been examined for 11 different soil constants. The samples were partly collected from 440 profile pits (yielding about 4,200 samples); the rest comprised special surface samples examined in connection with manurial experiments. Most of the data has already been published in articles describing the cacao soils of Trinidad. (F.H.)

of the soil, in contradistinction to *productivity*, which takes into consideration *all* the soil factors controlling plant-growth, both physical and chemical, including water and air supply, as well as "chemical" fertility.

Definitions of Terms used in the Scheme.

(1) The chief unit in modern schemes of soil classification is the *Soil Series*. This is defined as a group of soils having similar profile characteristics, and derived from the same kind of parent material. A Soil Series is usually named after the locality where it was first studied.

(2) By *Parent Material* of a soil is meant the mass of weathered rock from which the soil profile is developed by the operation of natural agents, such as percolating water, as well as biotic agents, such as growing plants and soil micro-organisms. It is often difficult to decide for Trinidad soils the separating line between parent material and parent rock, especially where this is a sedimentary fine-grained kind. Weathering of siltstones and claystones is usually very deep,* and manifests itself in various colour changes, most of which have little pedological significance. Accordingly, F. Hardy's conception of parent material as a deep soil horizon which, when followed downwards, shows no appreciable change in chemical and physical features, as expressed by routine laboratory data, has been accepted, rather than a definition based solely on appearance.

(3) *Soil Types* are members of a soil series,† differing among themselves in the texture of the surface layers. They are consequently given descriptive texture names after the soil series name, for example, Montserrat Loam; Montserrat Clay-Silt. A soil type must be sufficiently distinctive as to be mappable on morphological features alone; (appearance, structure, texture); a type which occupies less than three acres of land is usually not mappable on the 1 inch to 12 chains scale (1 : 9504), and such would not be admitted into the scheme.

(4) *Soil Phases* are the natural subdivisions of a soil type, showing only minor variations in profile characters, but differing markedly in external features, such as slope, degree of erosion, stoniness, &c., as well as in certain internal features, such as the prevalence of particular lithological, mineralogical or chemical components, notably concretions, stains, excess of salts (including gypsum and calcium carbonate), carbonaceous residues, &c. These may occur solely in the parent material of the soil, and their presence may not greatly affect the productiveness of the soil as a whole.

(5) *Soil Complexes* are cartographic units comprising assortments of two or more soil series, soil types or soil phases, which are so closely associated in the field that they cannot be delineated separately on the usual scale employed for soil mapping.

(6) *Soil Profile* is the vertical section (usually down to 6 or 10 feet) which reveals the stratification of the soil into horizons.*

The *colouration* of the soil profile is its most characteristic feature, and is largely employed in recognising soil types in the field. Only those colour variations that can be correlated with agricultural reputation and confirmed by laboratory analysis have been admitted into the scheme, for example:—

(*a*) Uniformly *black* or *red-brown* colours, extending to the full depth of the profile (4 to 6 or 10 feet), usually indicate good drainage and aeration, and denote high productivity.

(*b*) Uniformly bright *red* or *orange* colours generally indicate extensive leaching, low lime status and high acidity, but a fair to high degree of aeration, implying good natural drainage.

(*c*) *Mottled* colours indicate impeded drainage with intermittent aeration, not conducive to satisfactory root development; *red mottling* usually indicates high acidity, complete absence of free lime, and a very low combined (or exchangeable) lime status; *yellow mottling* in soils of hilly lands indicates a satisfactory lime status, though free lime may be absent; on the other hand, in low-lying soils, yellow mottling may be the result of waterlogging (constant wetness), with inadequate aeration.

(*d*) Uniform *grey* colours in low-lying clay soils indicate permanent water-saturation; *i.e.* drainage impedence.

* Weathering effects may be traced to depths greater than 20 feet in many of the silty and clayey sedimentary rocks occurring in Trinidad. (F.H.)

† Nearly all of the Soil Series so far identified in Trinidad contain *only one Soil Type*, because the lithological nature of the parent sedimentary rocks from which the soils have been mostly derived has impressed itself on their physical composition. Thus sandstones have given rise to loose sandy soils, siltstones to clay-silts, claystones and shales to heavy clays. Accordingly, and for the sake of simplicity, the term "Soil Series" has been omitted from Dr. Chenery's scheme as summarised in this article, and "Soil Type" substituted. (F.H.)

* In a typical soil profile, the topsoil (*A-horizon*) contains organic matter, either lying on the surface (Ao zone) or incorporated into the mineral soil (A1 zone). Often the bottom part of the A-horizon is eluviated, that is, deprived of certain components (such as oxides of iron, clay, &c.) by water-leaching (A2 zone) . . . The sub-soil (*B-horizon*) includes a zone of illuviation or accumulation (B2 zone), usually exhibiting characteristic colouration and structure. The deep subsoil or parent material (*C-horizon*) may also occasionally contain accumulations, such as concretions or crystalline salts. In waterlogged soils, it is frequently coloured blue-grey owing to the presence of ferrous compounds depending on prevailing reducing conditions. (*Gley* or G-horizon). (F.H.)

Productivity Rating.

This refers to the inherent capacity of the soil for producing the chief crops of the Island, without the intensive use of amendments, such as manures, fertilisers and lime, and without thorough artificial drainage. It assumes the careful husbandry of crops and proper orchard sanitation. The chief reference crops selected for assessing the producing capacity of the soils of Trinidad are *cacao* in the wetter (eastern) districts, *sugar-cane* in the drier (western) districts, and *coconut* in the coastal districts. This subdivision is clearly shown in the Land Productivity Map by thick lines arbitrarily separating the respective cropping districts. Only the most productive lands are suitable for the cultivation of market garden crops, and this fact should be borne in mind when sites are being selected as land settlements for peasants.

In Dr. Chenery's scheme, five grades of cacao land are recognised, namely :—

Grade I; Very high productivity. Land capable of yielding over 3 bags (500 lb.) of dry cacao per acre, and amenable of further improvement without much expenditure, by means of manures, lime, organic dressings, &c.

Grade II; High productivity. Land capable of yielding 2 to 3 bags (330 to 500 lb.) of dry cacao per acre, with possible economic improvement, as above.

Grade III; Medium productivity. Land capable of yielding 1 to 2 bags (165 to 330 lb.) dry cacao per acre; may be improved in some cases at reasonable cost by means of manures, lime, organic dressings, &c., by thorough draining on flat lands and terracing on hillslopes.

Grade IV; Low productivity. Land capable of yielding ½ to 1 bag (85 lb. to 165 lb.) dry cacao per acre. In a few cases, production may be improved economically by artificial means, but not generally.

Grade V; Very low productivity; yields less than ½ bag (85 lb.) dry cacao per acre. Land could not be improved, except at prohibitive cost.

Notes on the Classification Scheme.

(I) Free-Draining Soils.

The soil types* in this class comprise five open, porous, coarse to fine sandy soils, and four highly permeable, crumb-structured soils, containing appreciable amounts of lime-saturated clay. They are depicted in various shades of red and brown on the soil map. One of them is the remarkable "Chocolate Soil" (Montserrat Clay-Silt) having exceptionally high inherent productivity. Two other clayey types, Tamana Clay and Laventille Loam, are residual red soils (Terra Rossa), derived from hard limestones; they are deficient in nutrients, and are not ranked among the Island's productive cacao soils. The fourth clayey type is the only igneous rock soil in the Island. It occurs as a small coastal patch in the extreme north-east of Trinidad, and would be more productive to cacao were it not for the very high prevailing rainfall.

The sandy soil types include two Grade I soils, namely, Montserrat Loam (formerly known as Good Brasso Sand) and River Fine Sand (in part). These owe their fertility to the peculiar mineralogical composition of the parent soil material, which is glauconitic sand (Greensand) in the one case, and fresh, recent schist alluvium in the other.

A widespread cultivated sand type is the Caroni Sand (embracing soils previously named Bad Brasso Sand, Caroni Grey Sand, Moruga Yellow Sand and Sans Souci Metamorphic Grit). It is a loose, porous soil, derived from highly quartzose sands, variably, though lightly, stained red or yellow by iron oxides. Consequently, it generally shows only low productivity (Grade IV or V).

The remaining two sandy soils (Maracas Sand and Valencia Light Sand) are also unproductive types (Grade V), and, like the last, have been derived from nutrient-deficient parent materials. The Maracas soil occupies most of the Northern Range highlands and foothills, consisting mainly of quartzose mica-schist, though one phase is derived from red porcellanite (baked clay) which occurs chiefly in the Cedros Peninsula. The Valencia soil occupies a flat belt at the base of the foothills of the eastern part of the Northern Range, and is derived from sandy and gravelly detritus of quartzose-schist material, coloured usually white or grey, though occasionally bright orange-red. It is mainly covered by forest, for example, Mora forest, north-east of Sangre Grande, and mixed rain forest, at Arena.

(II) Partially-Impeded Draining Soils.

These soil types show a true water-table after heavy rainfalls. They comprise slowly permeable soils occupying low-lying sites, or hilly-land soils having compact and somewhat impervious subsoils, so that in either case, drainage is not altogether free. The colouration is yellow-brown, ochre, olive or grey, *never* red or red-mottled. The group includes clay-silts and heavy clays having medium to low cacao productivity. The types are depicted in shades of pink, orange and yellow on the soil map. One of the well-known clay soils (Princes Town Heavy Clay) is a Rendzina ("humus- carbonate" soil), derived from marlstone; two others (Marper Silt and Toco Loam) are also calcareous types, each having a highly productive phase (Grade I). The non-calcareous types include three alluvial soils (Sangre Grande Clay-Silt, L'Ebranche Clay-Silt, Frederick Heavy Clay) showing variable fertility. The most widespread soil-type of the group is Moruga Loam, derived from massive siltstone. It occupies large areas of hilly country in the south of the Island. The drainage is impeded by a compact impervious parent material. The last member of the group (Piarco Light Sand) is a loose

* Most of the soil types mentioned in this and the next section have been described elsewhere (*See* References), though no full and connected account of them has yet been published. (F.H.)

grey detrital sand overlying crimson-mottled white clay or sandy-clay occupying level country probably representing pre-existing llanos. Its main occurrence is in the savannas of the Northern Plain, though small areas also occur in the Cedros Peninsula, as well as in the southern part of the Waterloo Sugar Estates, and around Mt. Harris. It comprises the least productive soil in Trinidad; it is usually waterlogged during the greater part of the wet season.

(III) Impeded Draining Soils.

These are depicted in shades of blue, green and grey on the soil map. The seven soil types comprising this group include three *yellow clay* soils (Brasso Clay, Biche Heavy Clay, Ecclesville Clay), two of which are derived from calcareous parent materials, while the third is derived from fine siltstone, nearly devoid of calcium carbonate. They all have compact, coherent, impervious topsoils which tend to become water-soaked during part of the wet season, though they dry out and crack deeply in dry weather. No free water-table is evident in the profile, and red mottling is characteristically absent. The subsoil (parent clay) of the lower-lying representatives may exhibit a grey colouration indicating reducing conditions. These soils occasionally support very productive cacao (especially the non-eroded, non-gypseous phases of the Brasso Clay in East Trinidad), but they are mostly Grade II or Grade III soils.

Two of the remaining four soil-types (Ortoire Clay, Talparo Clay) are distinctively coloured *pinkish-red* or are *red-mottled* below.* This implies a low base status (low exchangeable calcium content), and consequently a very high degree of acidity. These two soils are unproductive of cacao (Grades III and IV), though variable in fertility.

The remaining two soil-types are placed by Dr. Chenery in a separate sub-group, designated "Soils having perennially high water-table due to low relief". One of them, the Nariva Heavy Clay, is a black to dark-grey swamp clay, presenting continuous anaerobic or reducing conditions. It occurs in the Nariva Swamp in east-central Trinidad. When drained, this soil-type might develop red mottling, and it would then be transferred to the last drainage group, probably Frederick Heavy Clay. The other soil, Cocal Light Sand, is a low-lying soil occurring along the eastern coast near the Nariva Swamp, and in the Cedros Peninsula, near the Icacos lagoons. It is quite unproductive of cacao (Grade V), but grows coconuts very satisfactorily.

* Recent investigations at the College have suggested that there may be three distinct kinds of red colourations developed in lime-deficient, highly acidic clay soils in Trinidad, namely (i) crimson mottling, (ii) red speckling, (iii) pink staining ("pink blush"). These may have different causes. Red mottling may result from differential leaching at the surfaces of structural elements, along small cracks or old root-traces, and it may appear in any part of the soil profile, including the deep parent clay. Red speckling mostly appears in the B-horizon; it may result from the accumulation of iron compounds leached down from the A-horizon above. Pink staining appears generally in the lower part of the A-horizon, where leaching is most actively occurring. It is thought to arise through the liberation and dehydration of ferric oxide from iron-bearing secondary clay minerals (such as nontronite) which break down or disintegrate when deprived of bases through profound leaching. According to this theory, clay minerals are stabilised by bases (potassium, sodium, calcium), but when substitution by hydrogen (hydrolysis) has proceeded far enough to deplete the minerals of their structural bases, they tend to split up into component oxides. (F.H.)

Crop Suitability.

Nearly one-half of Dr. Chenery's report deals with the suitability of the soil types to crops commonly grown in Trinidad. Among these, *market garden vegetable crops* are the most exacting, particularly in their water and nutrient requirements; they can be grown successfully without intensive manuring only on a small part (probably much less than 5 percent.*) of the available agricultural land. The suitable soils comprise five soil types only; they are the two Montserrat soils, River, Sans Souci and Marper types, at present planted in cacao. Certain other soil types, particularly Princes Town Heavy Clay and L'Ebranche Clay-Silt, as well as some river-flats soils, might prove suitable if manured, but most of remaining soils are considered to be economically unsuitable for vegetable growing.

Cacao.

With regard to cacao, the following grading is suggested by Dr. Chenery:—

Grade I: Montserrat Clay-Silt, Montserrat Loam, River Fine Sand (in part), Toco Loam (in part), Marper Silt (in part), Brasso Clay (in part). (6 soil types).

All these soils are naturally well-drained, but their nutrient status is not invariably high, so that they often benefit from manuring.

Grade II: River Fine Sand (in part), Toco Loam (in part), Marper Silt (in part), Princes Town Heavy Clay, L'Ebranche Clay-Silt, Brasso Clay (in East Trinidad). (6 soil types).

These soils are mostly well-drained clays having high lime status, but their nutrient status is variable and often deficient. Some are prone to landslip.

Grade III: Sans Souci Loam, Moruga Loam (in part), Sangre Grande Clay-Silt, Ecclesville Clay, Ortoire Clay (in part), (5 soil types).

These soils generally show faulty drainage and aeration; their nutrient status is variable, though usually low. They are not considered to be satisfactory cacao soils.

* A recent estimate by Dr. Chenery reduces this figure to 12 square miles (7,680 acres), or only 0.66 per cent. of the total area of Trinidad. (F.H.)

Grade IV: Caroni Sand (in part), Moruga Loam (steep phase in wet districts), Ortoire Clay (in part), Talparo Clay. (4 soil types).

These are mostly shallow, waterlogged soils, lacking nutrients; the clay types are prone to landslip, and the sandy types to surface erosion. Improvement by cultivation and manuring would be costly.

Grade V: Caroni Sand (in part), Maracas Sand, Valencia Light Sand, Piarco Light Sand, Frederick Heavy Clay, Nariva Heavy (swamp) Clay, Cocal Light Sand, (7 soil types).

These soils should never have been planted in cacao; they are the least satisfactory of all the soils of the Island. The sandy types are nearly devoid of nutrients and lime (except perhaps immediately after forest felling); they are very highly acidic. The clay types are liable to waterlogging and flooding; they also lack lime and are very highly acidic.

Citrus.

Because of the failure of many of the soil types to support cacao economically, trials of alternative crops have been made. Dr. Chenery has indicated the suitability of certain of the less-satisfactory cacao soils to the cultivation of Citrus, especially grapefruit, but only when they are drained, limed and heavily manured.* Thus, some phases of Sangre Grande Clay-Silt, Moruga Loam, Caroni Sand and Talparo Clay, classed as Grades III, IV and V for cacao, are put into Grade II for Citrus. Others are graded equally for cacao and Citrus, namely, River Fine Sand, L'Ebranche Clay-Silt and (in part) Brasso Clay. Some grapefruit fields have been formed out of inferior soils that were previously under second growth forest, or, in a few cases, under sugar-cane.

Tonka Bean.

Similar comments apply to the Tonka Bean soils of Trinidad. Tonka Bean appears to grow well on certain infertile sandy soils, namely, Caroni Sand (grey phase), Maracas Sand, Valencia Light Sand and Piarco Light Sand (well-drained phase), classed as Grade V for cacao. On the other hand, some of the best soils (for example, Montserrat Clay-Silt and Loam, Sans Souci Loam, Toco Loam, Princes Town Heavy Clay and Brasso Clay), classed as Grade I or II cacao soils, and notable for their high lime status, are regarded only as Grade IV or V soils for Tonka Bean. It appears therefore that Tonka Bean (and certain other crops, such as Cashew Nut, Mango and Pineapple) may grow reasonably well (but may not produce satisfactory yields) when planted on *acidic* soils of low lime status, provided they are porous and well drained. In many cases yields may be improved by suitable manuring.

* For example, dressings up to 10 lb. weight of complete artificial manure per tree for 5-years old grapefruit growing on sandy soil are recommended by the Department of Agriculture. (F.H.)

Sugar Cane.

The sugar cane soils of Trinidad for the most part have not previously been in cacao, but were gradually brought in from forest. They occur in the drier western part of the Island.* In recent years, some unproductive cacao lands occupying shallow central valleys in the Northern Plain or bordering the sugar cane lands have been converted into cane-fields. The sugar cane soils have recently been fully described by C. F. Charter (21), who has classified them into twenty-five soil series, grouped into seven suites. Most of these series have been identified and provisionally included by Dr. Chenery among his Island-wide types. They occur chiefly within low-lying river or swamp alluvial flats forming the Northern Plain (River Fine Sand, Sangre Grande Clay-Silt, Ecclesville Clay, Frederick Heavy Clay, Caroni Sand, Maracas Sand, Piarco Light Sand), or over the western part of the undulating peneplain comprising the Naparima District (Princes Town Heavy Clay, Talparo (red) Clay, L'Ebranche Clay-Silt, Ortoire Clay).

The productivity grades adopted for classifying these soil types are based on yields of "noble" (thick) canes grown without liming and intensive manuring. By planting thin-stemmed canes, or using appropriate manures and lime, the lower soil grades may be rendered profitable under good estate management. The only sugar-cane soil put into Grade I (because of its natural high fertility) is Princes Town Heavy Clay. Three other soil-types are classed as Grade II; two of these are alluvial soils, while the third is Brasso Clay derived from calcareous siltstone. All the sandy soil types are placed in Grades IV and V sugar cane soils; they dry out badly in the dry season, and their fertility status is too low for satisfactory cane growth.

Other Crops.

Coconuts thrive best in the loose open-structured Cocal Light Sand, which is naturally well supplied with fresh moving water because of proximity to the natural reservoirs of the Nariva and Icacos Swamps. Soil types that are heavy textured, compact, badly aerated and waterlogged, and lacking in potash are not suited to coconuts, nor are shallow phases of calcareous soils in which excessive free lime occurs at or near the surface.

Bananas thrive best on Grade I cacao soils in districts having high rainfall; *coffee* has similar or less exacting requirements than cacao; while *Hevea rubber* grows successfully on a wide range of soil types, provided the annual rainfall is above 100 inches.

Manuring for Increased Crop Production.

Though not considered in Dr. Chenery's report, much information has accumulated relating to manuring responses of the different soil-types,

* The annual rainfall of western Trinidad is less than 65 inches. It is doubtful whether sugar-cane would ripen properly if grown in the wetter (eastern) part of Trinidad, particularly on heavy, low-lying clays, and during years having unpronounced dry seasons. (F.H.)

consequent on the initiation in 1932 by the College Department of Chemistry of a series of manurial experiments on cacao. The results have been recorded in the Annual Reports on Cacao Research. The experiments have been extended since 1936 by the Trinidad Department of Agriculture, and Dr. F. J. Pound (Cacao Agronomist) has assumed responsibility for them. Dr. Pound's progress reports have been summarised by the writer in recent Cacao Research Reports. In the Ninth Annual Report, the particular soil-types that were examined by manurial experiments have been arranged according to Dr. Chenery's classification scheme. Detailed information on manurial responses has thus been obtained for the following soil-types; the number of Latin Square experiments and of other kinds of manurial trials are given after the name of each soil type :—

(i) River Fine Sand (16 ; 31) ; (ii) Sangre Grande Clay-Silt (9 ; 19) ; Ortoire Clay (8 ; 25) ; (iv) Princes Town Heavy Clay (4 ; 16) ; (v) Brasso Clay (2 ; 16) ; (vi) Caroni Sand (1 ; 12) ; (vii) Ecclesville Clay (1 ; 5).

The certainty of response to manuring varies in the different cacao soils. Two main factors appear to decide the degree of response, namely, soil structure and nutrient status. Thus, only those soil types that exhibit an open structure, favouring rapid movement of water and air, and allowing the development of healthy root systems, seem to benefit from manuring. Among them are *River Fine Sand* and certain phases of *Caroni Sand* and *Moruga Loam*, provided they are thoroughly drained. These soils belong to the " free drainage" group because of their porous sandy texture. They respond chiefly to potash manures ; increases of cacao yield varying from 35 to 75 per cent. have been recorded for River Fine Sand manured with potassium sulphate, 1½ or 2 lb. per tree.

Other soil types that respond to manuring are those derived from calcareous parent materials, for example, *Princes Town Heavy Clay*, *Brasso Clay*, *Marper Silt* and *Toco Loam*. These possess a good crumb structure induced partly by a high lime status ; they usually benefit by artificial draining. They respond most to phosphatic manures because of their inherently low phosphate status.

Soil types derived from non-calcareous parent materials, for example, *Sangre Grande Clay-Silt*, *Ortoire Clay* and *Ecclesville Clay*, are structureless, compact, badly drained and badly aerated. For this reason, cacao root systems do not develop satisfactorily in them, and, although they may be deficient in nutrients, they rarely respond to manuring.

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A TENTATIVE SCHEME FOR THE CLASSIFICATION OF THE SOILS OF TRINIDAD: AFTER E. M. CHENERY; 1939.

	Previous names.	Parent Rock.	A-horizon.	B-horizon.	C-horizon.	Phases.	(A) Fertility Status. Lime Content. (i)	O.M. Content. (ii)	Avail. P_2O_5 (iii)	Avail. K_2O (iv)	(B) Productivity Grades. Cacao (i)	Sugar-cane. (ii)	Citrus. (Manured) (iii)
(I) *Drainage free*: Sands, loams, friable crumby silts and some clays. High porosity and permeability. Very low water-table.													
Calcareous Parent Materials.													
1. (A) Montserrat Clay-Silt	Chocolate Soil ...	glauconitic limestone	dark-brown	red-brown	green-brown	b, c, d, j, k, n.	1	1	1	1	I	(I)	(I)
(B) Montserrat Loam	Good Brasso Sand ...	glauconitic sandstone	do.	do.	grey-brown	b, c, d, j, n.	1, 2	1	1	1	I	(I)	(I)
2. Tamana Clay ...	Limestone Soil ...	hard limestone	do.	yellow-brown	yellow-brown	b, c, n.	1, 2	2	–	–	II-IV	(IV)	(IV)
3. Laventille Loam ...	do. ...	do.	red-brown	red	pale-red	b, c, n.	1, 2	2, 3	–	–	(V)	(V)	(IV)
Non-calcareous Parent Materials.													
4. River Fine Sand ...	Northern Range Alluvial Soil	schist alluvium	sepia	orange-brown	tawny	a, d, g, m.	2	2, 3	2, 3	3	I, II	I, II	I
5. Caroni Sand ...	Caroni Grey Sand; Bad Brasso Sand; Moruga Yellow Sand; Sans Souci Grit	loose sand, sandstone, grit or schist	grey-brown	yellow	yellow-grey	b, c, d, e, g, m, n.	3	2, 3	3	2, 3	IV, V	IV	II
6. Sans Souci Loam ...	Igneous Soil ...	diorite	brown	tawny	golden-brown	b, c, d, g, j, k, n.	(2)	1, 2	1, 2	3	III	(III)	(III)
7. Maracas Sand ...	Esperanza Suite; N. Range Schist Soil	mica schist, porcellanite	do.	red	pink	b, c, d, g, m, n.	(3)	3	3	3	V	IV, V	III, IV
8. Valencia Light Sand	Detrital Sand ...	loose white, grey or red sand	dark-grey	pale-grey	grey, yellow or red	b, c, d, g, m, n.	(3)	3	3	3	V	V	IV
(II) *Drainage partially impeded*: Loams, marly-silts, marly-clays and sandy-clays. Medium porosity and permeability through partial compaction, restricted perviousness of parent soil material, or depressed topography; intermittently high water-table.													
Calcareous Parent Materials.													
9. Toco Loam ...	Toco Calcareous Schist Soil; La Carriere Shale Soil	calcareous schist and shale	dark-brown	yellow-brown	grey to black	b, c, d, j, n.	(1)	1, 2	1, 2	2	I-II	(III)	(III)
10. Marper Silt ...	Brasso Silt; Moruga Marly-Silt	calcareous siltstone	do.	ochre	brown-yellow	b, c, d, f, j, k.	1	2	2	2	I, II	(I)	(II)
11. Princes Town Heavy Clay	P. T. Black Marl; Hermitage Clay	marlstone	black	black	grey, yellow-buff	b, d, g, h, k.	1	1	2, 3	1, 2	II	I	(III)
Non-calcareous Parent Materials.													
12. Moruga Loam ...	Moruga Yellow Silt ...	siltstone, shale	sepia	yellow	grey-brown	b, c, d, k.	3	2	2	1, 2	III, IV	IV	II
13. L'Ebranche Clay-Silt	Central Range Alluvial Soil	river alluvium	pale-brown	olive, ochre	yellow	a, d, g, j, k.	(2)	2	2, 3	2, 3	II	I, II	II
14. Sangre Grande Clay-Silt	S.G. Alluvial Soil; Washington Series	do.	yellow-brown	pale-brown ochre	yellow-grey	a, d, g, j, k.	(2, 3)	2	2, 3	2, 3	III	III	II
15. Frederick Heavy Clay	Caroni Clay; Frederick Series	swamp clay	black	dark-grey	grey	a, g.	(3)	2	3	2	V	II	V
16. Piarco Light Sand-on-Clay	Detrital Sand; Mt. Harris Grit; Waterloo Suite; Devenish Suite	loose sand over white clay	black to grey	pale-grey crimson-mottled	white, yellow-patched	a, b, c, g, j, m, n.	(3)	2, 3	3	3	V	V	V
(III) *Drainage impeded*: Mostly stiff clays. Low porosity and permeability through compaction, restricted perviousness of topsoil, or depressed topography.													
(A) *No true water-table.*													
Calcareous Parent Materials.													
17. Brasso Clay	Good Brasso Clay; Green Clay; Marly Clays; Tarouba Series	calcareous siltstone and shale	sepia	olive	olive, ochre	a, b, c, d, f, g, h, j, k, l, n.	1, 2	1, 2	2	2	II	II	II, III
18. Biche Heavy Clay	Eocene Marl Soil ...	marl	black	yellow	yellow	b, j, k.	(1)	2	2	1, 2	II	(I)	(III)
Non-calcareous Parent Materials.													
19. Ecclesville Clay	Bad Brasso Clay; Bad Green Clay; Talparo Yellow Clay; Fyzabad Brown Clay	fine siltstone	brown	yellow	grey	b, c, f, g, h, i, j, k.	2, 3	2, 3	3	2, 3	I I	II, III	III
20. Ortoire Clay	N. Alluvial Clay; Guapo Alluvial Clay; Debe Alluvial Clay	alluvial clay	dark-brown	grey	grey mottled-red-brown	a, d, j.	(3)	2, 3	3	2, 3	III-V	II, III	(III)
21. Talparo Clay	Red-Weathering Brasso, Talparo, Charuma and Naparima Clays	siltstone	yellow-brown or salmon	grey, mottled-red	grey	b, d, f, g, h, i, j, l.	3	2, 3	3	2, 3	IV	III, IV	II, III
(B) *Perennially high water-table, due to low relief.*													
22. Nariva Heavy Clay	Nariva Swamp Soil; Nariva Fasc.	swamp clay	black	dark-grey	dark-grey	a, i, j, l.	(3)	1	1, 2	3	V	V	V
23. Cocal Light Sand	Cocal Sand ...	beach sand	dark-brown	yellow	yellow	a, g, i, m.	(3)	1-3	–	–	V	V	V

KEY TO INDEX NUMBERS AND PHASES.

(A) SOIL FERTILITY STATUS.

Assessment Scale.	(i) Lime Status (Degree of Saturation by Lime) (per cent.)	(ii) Organic Matter Status (Total content) Sands; Loams (per cent.)	(ii) Organic Matter Status (Total content) Silts; Clays (per cent.)	(iii) Available Phosphate (P_2O_5-Truog) Sands; Loams (p.p.m.)	(iii) Available Phosphate (P_2O_5-Truog) Silts; Clays (p.p.m.)	(iv) Available Potash (Exch. K_2O) Sands; Loams (p.p.m.)	(iv) Available Potash (Exch. K_2O) Silts; Clays (p.p.m.)
1. High ...	90-100	4.0-6.0	5.0-7.0	40-80	65-135	140-250	240-450
2. Medium ...	70- 90	2.0-4.0	3.0-5.0	20-40	35- 65	60-140	110-240
3. Low ...	30- 70	0-2.0	0-3.0	0-20	0- 35	0- 60	0-110

Note.—All values based on laboratory determinations, except where bracketed.

(B) PRODUCTIVITY RATING.

	(i) Cacao. (lb./ac.)*	(ii) Sugar-cane. (tons/ac.)†	(iii) Citrus (Manured) (boxes/ac.)‡
Grade I—Very high	500 or over	40 and over	300 or over
II—High	330-500	25-40	200-300
III—Medium	165-330	15-25	150-200
IV—Low	85-165	5-15	100-150
V—Very Low	0- 85	0- 5	0-100

* dry cured cacao bean; 300 trees/ac. † plant canes. ‡ 50 trees/ac.

Soil Phases.

Slope phases / *Erosion phases*: (*a*) flat, (*b*) undulating, (*c*) steep. (*d*) sheet-eroded (surface-washed). (*e*) gullied.

Truncated phases: (*f*) land-slipped. (*g*) humic layer absent. (*h*) exposed layer gypseous or highly calcareous.

Lithological phases (Parent material, or C-horizon): (*i*) gypseous or saline. (*j*) concretionary rusty ironstone. (*k*) concretionary or superficial black manganese oxide. (*l*) lignitic or carbonaceous.

Land surface: (*m*) pebbly. (*n*) bouldery.

MODERN SYNTHETIC RUBBERS.

The following account is taken from an article by K. Frolich which appeared in *News Edition*; *American Chemical Society*, **18**, 7, pp. 285-286, 1940.

The developments of synthetic rubber chemistry date back only to some 15 years ago. Although Germany's annual production at the end of the last World War had attained four million pounds weight of synthetic rubber, subsequent production has not been particularly rapid. The reason is not difficult to find. The earlier object was solely to develop an imitation plantation rubber, such as could compete with it in the open market. The main aim was to keep costs down. The high prices ruling in 1908-10 stimulated scientific effort, and the last war further encouraged research. Nevertheless, the basic principle was wrong. Modern methods no longer aim at competition with low-priced plantation rubber, but rather at exceptional quality in the synthetic product. Like most naturally-occurring products, rubber has certain shortcomings that limit its applications. Its strong point is its peculiar molecular structure which accounts for its elastic properties and mechanical strength. Its weak point is its pronounced chemical reactivity which is responsible for low resistance to oxidation, lack of heat stability, and susceptibility to acids. While the first work endeavoured to duplicate Nature's product, the present effort is to reproduce, or even to improve upon, structural characteristics of the rubber molecule. Extensive researches initiated by the I. G. Farbenindustrie in 1927 with such a goal in mind led to the development of products known as Buna rubbers. Working along entirely different lines, but following the same principle, the du Pont interests developed Neoprene.

The chief synthetic rubbers manufactured today are:—

Buna (generally accompanied by a number referring to specific physical properties). A straight butadiene polymer. In this class also falls the product manufactured in Russia.

Buna S. A co-polymer of butadiene and styrene.

Perbunan (also referred to in earlier publications as Buna N). A co-polymer of butadiene and acrylonitrile.

Perbunan Extra. Same type as Perbunan, but with a higher content of acrylonitrile.

Neoprene. A polymer of chloroprene.

There is also a class of intermediate products which, although they possess definite elastic properties, do not lend themselves to the characteristic type of vulcanization because of their chemical saturation. These are *Koroseal*, a polymer of vinylchloride; *Thiokol*, a condensation product of aliphatic chlorine-containing compounds and sodium polysulphide; and *Vistanex Polybutene*, a linear polymer of isobutylene.

Although Nature's rubber production probably is the outcome of a series of condensation reactions involving oxygenated intermediates, from a structural standpoint, the rubber molecule can be considered a polymer of isoprene, or 2-methyl butadiene. The original methyl rubber manufactured in Germany was made from 2, 3-dimethyl butadiene, simply because this diolefin could be made available more readily than isoprene at that time. The present choice of butadiene and chloroprene (*i.e.*, 2-chloro-butadiene) as raw materials for synthetic rubber production is probably also largely a matter of availability and cost. No published information leads to the conclusion that isoprene would be less suitable for the manufacture of a satisfactory product by present polymerization methods.

The first Buna rubber was produced by bulk polymerization of butadiene with metallic sodium as the promoter, the name having been derived from this combination. This also was a slow procedure and, as it did not lend itself to the production of co-polymers containing polar compounds, was abandoned in Germany for emulsion polymerization. Judging by the limited published accounts, however, the method is still in use in Russia. With the emphasis on co-polymers of the Buna S and Perbunan type, Buna rubbers are now being produced by the emulsion technique. The ingredients are emulsified with water and subjected to conditions of temperature and pressure suitable for converting them into a suspension of synthetic rubber which resembles the latex obtained from a rubber tree. Compared with older methods, the polymerization proceeds quite rapidly. Although the process requires close control, it does not present any problems that differ greatly from those ordinarily met with in modern chemical manufacturing operations. Recovery of the synthetic rubber from the emulsion is similar to the recovery of the natural rubber from latex.

Buna S is finding extensive use in German manufacture of automobile tyres which resist wear and have a longer life than those from natural rubber. Perbunan is widely utilized in fields where its special properties give it an advantage over natural rubber. The chemical substances consumed in the manufacture of these and other rubber polymers are petroleum derivatives and, with the petroleum industry's past record for large-scale operation at low cost, there is every reason for considerable expansion in the field of synthetic rubber production.

The subscription to *Tropical Agriculture* is six shillings per annum, post free, to all countries within the British Empire or seven shillings and sixpence, post free, to all other countries. Subscriptions can commence at any time during the year.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

Active Aluminium in British Guiana Soils. D. W. Duthie and C. L. C. Bourne, in *Agricultural Journal British Guiana* X, 3, pp. 113-123.

A striking fact in the sugar-cane agriculture of British Guiana is that the cane-soils were all distinctly alkaline some thirty years ago, whereas they are now practically all markedly acidic, *i.e.* and the acidity is still increasing. This change has been ascribed to the general use of ammonium sulphate (which is physiologically acid), as a fertilizer. Present opinion however inclines to the view that the original change from alkaline to acidic is more to be ascribed to the leaching out of alkaline salts than to liberation of acid from ammonium sulphate.

It also appears that the undesirable effects of acidity are intensified when the acidity becomes great enough to promote solution of aluminium salts in the soil water. This soluble or "active" alumina has a direct toxic action on the cane roots, and the poisoning action becomes particularly noticeable at a pH of about 4.7. Liming is especially necessary to counteract this phenomenon. Beyond that, liming of acid soils to neutrality has not in general proved to be economic.

More beneficial than simple liming is the practice of flood-fallowing the cane-fields every fourth year. The flood water removes soluble salts and promotes reactions that raise the available calcium content of the soil; it also results in a marked improvement of the soil's physical condition and tilth. To guard against the increasing acidity from annual applications of ammonium sulphate fertilizer, it is advisable to add ½ to 1 ton of limestone at planting time. If this is done, the adverse effects of increasing acidity may be prevented, or delayed indefinitely.—(*Facts About Sugar*, **35**, 3, p. 34, 1940.).

* * *

Formation of Mucus in Decomposing Plant Materials.

The decomposition of a number of plant materials in the presence of sulphate of ammonia and sodium nitrate and without any treatment was studied with regard to the question of stickiness as caused by the formation of mucus.

Initial high protein content of a plant material was found to have no direct bearing on the amount of stickiness, but indirectly to affect it through the degree of decomposition. A difference thus seems to exist between the synthesised microbial protein and the original plant protein with respect to the production of stickiness.

Provided the reaction developed is suitable, production of stickiness during fermentation appears to be independent of the nature of the plant material, with the exception of plant materials containing tannin. The presence of tannins in refuse tea, tea-leaf prunings, and Gordonia was shown to exert a toxic effect on the microflora concerned in the decomposition; the inhibition of mucus production seems to be a microbial process rather than a chemical one. The production of stickiness indicates the reaction and, in the light of previous work, the nature of fermentation (whether aerobic or anaerobic) of a fermenting vegetable heap.—(J. G. Shrikhande, *Soil Science*, Vol. 49, No. 1. p. 1, 1940.)

* * *

Carbohydrate Manuring.

Indian soils normally contain much less nitrogen and organic matter than those of more temperate regions, and the use of molasses as a fertilizer has received considerable attention and met with some success. Recently, N. R. Dhar of Allahabad has claimed remarkable increases in nitrogen fixation by the use of molasses and other energy-rich materials, including fats. An account of this work was presented at the First International Fertilizer Congress in Rome in 1938, and is summarized by H. E. Z. Raczkowski in *Hadar* (Nov. 1938), the Palestine citrus journal. According to Prof. Dhar, carbohydrates, glycerol, paper, straw, sawdust, &c., increased nitrogen fixation. Light is said to be utilized as in photosynthesis. In field trials, three tons of molasses added 112 lb. of nitrogen per acre, and ten tons fixed 270 lb. of nitrogen. The nitrogen thus fixed was retained in the soil much longer than when ammonium sulphate was added. In sterilized soil, nitrogen fixation occurred in the complete absence of micro-organisms, provided light was available. It is thus claimed to be a photo-chemical process. Contrary to the general belief, Prof. Dhar says that fats are readily oxidised in tropical soils and provide considerable energy for nitrogen fixation.—(*Nature*, Vol. CXLV, No. 3677, p. 632, 1940.)

* * *

Effect of Sterilisation and Storage on Anti-scorbutic Power of Lemon Juice.

Sterilisation of fresh lemon juice for 1½ hours at 120°C. caused no appreciable loss of anti-scorbutic power; 5 ml. of either fresh or sterilised juice per day protected 250 to 300-g. guinea pigs on a vitamin-deficient diet over a test-period of 100 days; 3 ml. per day appeared to give satisfactory results up to a 30-day test-period, but subsequently slight scorbutic symptoms were observed, although the weight increase was normal or nearly normal. Lemon juice, whether freshly pressed or sterilised, rapidly lost its anti-scorbutic properties when kept in a vessel open to the air. Values obtained for the "iodine index" of lemon juice were as follows: freshly-pressed juice, 75 mg. per 100 ml.; sterilised, 70 mg. per 100 ml.; kept in contact with the air, 55.5 mg. per 100 ml. (after 8 days), 25.3 mg. per 100 ml. (after 15 days), 10.4 mg. per 100 ml. (after 20 days); kept under nitrogen, 70.4 mg. per 100 ml. (after 70 days).—(*Analyst*, Vol. 63, No. 744, p. 201.)